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METHOD AND APPARATUS FOR INTERFACING TELEPHONE APPARATUS TO A DIGITAL, ANALOG OR HYBRID TELEPHONE SWITCHING SYSTEM

Related Applications:

This application claims priority under 35 U.S.C. § 119(e) of the co-pending U.S. provisional application Serial Number 60/166,670 filed on November 19, 1999 and entitled "Method And Apparatus For Interfacing Analog Telephone Apparatus To A Digital, Analog Or Hybrid Telephone Switching System." The provisional application Serial Number 60/166,670 filed on November 19, 1999 and entitled "Method And Apparatus For Interfacing Analog Telephone Apparatus To A Digital, Analog Or Hybrid Telephone Switching System" is also hereby incorporated by reference. This application is also a continuation-in-part of U.S. Patent Application Serial No. 08/994,212, filed December 19, 1997 and entitled "Method And Apparatus For Interfacing Analog Telephone Apparatus To A Digital, Analog Or Hybrid Telephone Switching System," which is also hereby incorporated by reference. This application is also a continuation-in-part of U.S. Patent Application Serial No. 08/994,211, filed December 19, 1997 and entitled "Method And Apparatus For Interfacing Analog Telephone Apparatus To A Digital, Analog Or Hybrid Telephone Switching System," which is also hereby incorporated by reference.

The contents of U.S. Application Serial No. 08/625,398, filed March 27, 1996, are hereby incorporated by reference.

Field of the Invention:

The invention relates to the field of telephony. More particularly, the invention relates to an adaptive interface for interfacing one of a digital, analog or hybrid telephone switching system to one of analog, digital or hybrid telephony equipment.

Background of the Invention:

Conventionally, telephony users received a direct connection to the Central Office (CO) as shown in Figure 1. For example, the CO 500 can be connected to an analog telephone 502, to analog conference call equipment 503, to analog headset equipment 505, to an analog facsimile (fax) machine 504 or to an analog modem of a computer 506.

Many users of telephony equipment utilize a PBX to provide convenience or enhanced features or both over conventional analog telephony equipment. Figure 2 shows a conventional PBX interface. Where appropriate, the same reference numerals will be used to represent the same elements. Here, the CO 500 is coupled directly to a PBX 510; the PBX 510 is typically located at the user's facility. Typically a PBX 510 will only communicate with PBX telephones 508 or with a voice mail system (not shown) or an e-mail gateway (not shown). As is well known, a PBX 510 will only allow communication with devices that are specifically configured for such PBX communication. A PBX 510 will not allow users access to conventional analog telephones 502, analog conference call equipment 503, analog headsets 505, fax machines 504 or analog modem of a computer 506. Similarly, a PBX 510 does not allow access to the internet cloud 516. Likewise, a PBX 510 does not allow a user to utilize different PBX telephones 514 that are configured to operate with other PBX equipment.

Previously, as shown in Figure 3, at facilities that utilized a PBX for voice communications, additional conventional service lines directly to the CO 500 were required to provide communication to an analog telephones 502, analog conference call equipment 503, analog headsets 505, analog facsimile (fax) machine 504 or to an analog modem of a computer 506. This was because the communication protocols used by a conventional PBX 510 are incompatible for use with analog equipment. Similarly, a PBX 510 of one type could not communicate with PBX telephones 514 of another type because their respective communication protocols were incompatible. A conventional PBX 510 also does not allow VoIP communication via the internet 516 through the PBX.

A two-wire analog telephone set of the type commonly found in the homes of telephone service subscribers typically includes a base unit connected to a central office of a telephone

service provider via a bi-directional, two-wire, telephone line and also includes a handset connected to the telephone base unit via a four-wire handset cable. The handset cable has four wires because, for two-way voice communication, the handset includes both a microphone and a speaker, each of which requires a pair of wires. Typically, the telephone base supplies audio signals to the speaker and a DC biasing voltage to the microphone, while the telephone base receives audio signals from the microphone. A two-wire to four-wire converter included in the telephone base unit converts the two central office wires into the four handset wires. In addition, the telephone set includes a ring detector for detecting an AC ring signal provided by the central office and a hook-switch for signaling the central office for answering or placing calls. When the handset is removed from its cradle, the hook switch allows DC loop current to flow from the central office by the telephone set which is detected by the central office.

A conventional modem transmits digital data over a two-wire telephone line by modulating an analog carrier signal according to the digital data. Typically, the digital data is generated by a computer or facsimile machine connected to the modem. The carrier signal is a tone within the frequency range of telephone transmission line. Upon reception by a second modem at the other end of the transmission line, the digital data is reconstructed by demodulating the received signal.

Business organizations often utilize a telephone switching system for providing telephone service to telephone users within the organization. The telephone switching system can have an all-digital interface with its corresponding compatible telephone sets, such as in a digital private branch exchange (PBX). Alternately, the telephone switching system can have an all-analog interface, such as is provided by an analog line card in a PBX or by a central office. In addition, the telephone switching system can provide a combined digital and analog interface with its corresponding compatible telephone sets, such as in a hybrid PBX or a key telephone system (KTS). For the purposes of this document, the term "PBX" is utilized to encompass equipment similar to those above-listed types of telephone switching equipment.

Telephone sets that are compatible with a particular PBX utilized by a business organization are located on the desks of the users. Each PBX-compatible telephone set is

connected to the PBX via a corresponding extension line, while the PBX is connected to a telephone service provider via one or more outside lines. The PBX typically includes capability for appropriately connecting incoming calls to the user telephone sets and for connecting outgoing calls from the user telephone sets to an outside line. In this way, fewer than one outside line per telephone set is needed, thus, reducing the cost of the telephone service. In addition, the PBX typically provides a variety of features to the users of the PBX, such as connecting calls among the users and providing voicemail services.

To implement all of the functions of the PBX, certain control and overhead communications must take place between each user's telephone set and the PBX. These communications typically include digital status, initialization and command signals in addition to the two-way voice signals necessary to carry on a telephone conversation. For example, the PBX must know whether a telephone set is connected to a particular extension line in order to know whether or not to route calls to that extension. As another example, the PBX must interact with the user telephone sets in order for the users to receive incoming calls, initiate outgoing calls, terminate telephone calls and to access voicemail and other features of the PBX.

In general, communication protocols utilized for control, overhead and voice communications differ among the various manufacturers of PBX's. In addition, in an all-digital PBX, the voice signals are communicated between the telephone sets and the PBX as digital samples. Thus, analog voice signals are digitally sampled and encoded according to various schemes (e.g. μ-law or A-law) before they are communicated. Upon reception, the digital samples are decoded and converted back into analog voice signals. In a hybrid system, voice signals are communicated as analog signals, while control and overhead communications are digital signals. Therefore, a two-wire analog telephone instrument, such as a modem, fax modem, facsimile machine or teleconferencing device, cannot generally interface directly with a PBX proprietary interface port or line card. Nor can a four-wire analog telephone instrument, such as a headset, handset or modem, generally interface directly with a PBX.

This creates a problem for users of a PBX who wish to use universally available analog telephone instruments, such as modems, fax modems, facsimile machines, teleconferencing

devices, headsets or handsets, in addition to their PBX-compatible telephone sets. This problem has intensified by the recent increase in demand for access to the world wide web, which is typically accessed through use of a modem connected to a personal computer. One solution has been to provide a dedicated outside line for each such analog telephone instrument. This solution is not entirely satisfactory, however, because it negates the savings which result from the PBX limiting the number of required outside lines. Another solution has been to provide an analog line card in the PBX and a separate line connecting the two-wire analog telephone instrument to the PBX. This solution can be costly due to the need to install separate extension lines to connect each of the PBX-compatible telephone set and the analog telephone instrument to the PBX.

Another solution has been to provide a device which interfaces a modem with a telephone set through the handset port of the telephone set. For example, U.S. Patent No. 4,907,267 discloses a modem interface device for use with a telephone set having a base unit and a handset. The telephone set can be a two-wire telephone set or a telephone set designed for use with a PBX. To use the modem interface device, the handset is unplugged from the handset jack of the base and plugged into a handset jack in one end of the device. Extending from the device is a four-wire cable which is connected to the handset jack of the base. The device also includes a modular jack for accepting a two-wire cable which connects the device to a two-wire telephone instrument, such as a modem. A series of switches are manually positioned to select between voice and data communications and to configure the interface device to match the signaling characteristics of the particular telephone set being used.

The manually operable switch arrangement described in U.S. Patent 4,907,267 is improved upon in two products manufactured by Unlimited Systems Corp. of San Diego, California. A first of these products, the "KONEXX Office Konnector," connects to the base of a telephone set and to the handset to provide an interface for a two-wire telephone, facsimile machine or modem. The device detects when the two-wire telephone, facsimile machine or modem is placed off-hook for switching between voice and data communications. A second of these products, the "KONEXX Konference," is similarly connected between the base and

handset, but provides an interface for a teleconferencing device. For each of these devices, a manually operable switch is positioned in one of four positions for adjusting the device to the signalling characteristics of the particular telephone set being used.

The aforementioned interface devices, however, can be inconvenient for interfacing an analog telephone instrument to a PBX. This is because to install such an interface device, the handset cord of a PBX-compatible telephone set must first be disconnected from its base. Then, the interface device must be connected to both the handset and to the base. Next, the analog telephone instrument must be connected to the interface device. Finally, the switch positions for the interface device must be correctly set.

Perhaps a more significant drawback, however, is that each time the analog telephone instrument is used to answer or place a call, the user must manually place the PBX-compatible telephone set off-hook. This is generally accomplished by removing the handset of the PBX-compatible telephone from its cradle. Similarly, when finished using the analog telephone instrument, the user must return the PBX-compatible telephone to its on-hook condition. Otherwise, if the user forgets to return the PBX-compatible telephone to its on-hook condition, incoming calls cannot be connected and will receive a busy indication. In addition, the handset port of the PBX-compatible telephone generally does not provide a ring signal which may be required for automatic answering functions. Another drawback is that some PBX-compatible telephones communicate dialing information via digital bit streams and will not recognize DTMF tones (“dual tone, multi-frequency times as well known in the literature of telephony”) presented at the handset port as dialing commands. Thus, for example, auto-dialing features of an analog device will fail to operate. Therefore, the actual telephone keypad must be used to dial for the analog device. Furthermore, the cables required for connecting such an interface device can become tangled and tend to provide a cluttered appearance on the user's desk.

Therefore, what is needed is a technique for interfacing an analog telephone instrument to a PBX that does not require access to the handset port of a PBX-compatible telephone. What is further needed is such a technique that has sufficient flexibility to adapt to the signaling characteristics of a wide variety of commercially available PBX's. What is still further needed is

such a technique that requires a minimum of additional cables to accomplish its functions and that minimizes technical ability required from a user. What is further needed is an apparatus and method that provides users flexibility in selecting among PBX systems, telephone sets and telephony appliances, regardless of manufacturer and have an ability to mix equipment designed to operate according to different protocols. Additionally, what is needed is a method and apparatus that will allow a user to interface any of a plurality of PBX systems to a digital port such as a USB port, ethernet port or the internet, among others.

Summary of the Invention:

The invention is an adaptive interface method and apparatus for interfacing a two-wire analog telephone instrument, such as a modem, fax modem, facsimile machine or teleconferencing device, or a four-wire analog telephone instrument, such as a headset, a handset or a modem, to a private branch exchange (PBX) or digital computer link such as a USB link, an ethernet link, internet or the like. For purposes of this document, the term "analog telephone instrument" will be used to refer to both two-wire and four wire telephone instruments. The interface device according to the present invention is suitable for use with a variety of PBX's produced by different manufacturers, despite differences in signaling characteristics between the PBX and an associated PBX-compatible telephone. In a preferred embodiment, the invention does not require access to a handset port of the PBX-compatible telephone.

A PBX is generally connected to an associated PBX-compatible telephone via a two, four or eight-wire telephone extension line. In a first embodiment of the present invention, the interface device is connected to the extension line. The interface device will preferably include at least four communication ports, a first port for a proprietary telephone set, a second port for a two-wire analog adjunct port, a third port for a four-wire analog adjunct port and a fourth port for a USB port. An analog telephone instrument can then be connected to the interface device via one of the two-wire or four-wire analog adjunct ports. Alternatively, the two analog ports could be combined into a single port. Under that circumstance, the interface device would determine whether the analog device was a two-wire analog device or a four-wire analog device and

configure the port appropriately. Likewise, more ports can be added without departing from the spirit and scope of the present invention. The PBX-compatible telephone communicates with the interface device which in turn communicates with the PBX so as to notify the PBX that the extension line is capable of receiving incoming calls. In addition, a PBX-compatible telephone can initiate and receive telephone calls via the interface device.

The analog telephone instrument can also initiate and receive telephone calls. To initiate an outgoing telephone call originated by the analog telephone instrument, the interface device detects a current draw (off-hook state loop-current) by the analog telephone instrument, as occurs when the analog telephone instrument goes off-hook. Accordingly, the interface device emulates a central office from the perspective of the analog telephone instrument. In response to detecting the analog telephone instrument going off-hook, the interface device communicates an appropriate instruction to the PBX so as to emulate the PBX-compatible telephone going off-hook. This is accomplished without having to manually take the PBX-compatible telephone off-hook. According to the first embodiment, a telephone number to be called is dialed by using a keypad located on the interface device or adjunct device.

To receive an incoming call using the analog telephone instrument, the interface device receives a notification of the incoming call which is sent by the PBX and intended for the PBX-compatible telephone connected to the corresponding extension line and sends "ring" signals to the adjunct ports. If the analog telephone instrument then goes off-hook, the interface device responds by communicating an appropriate instruction to the PBX so as to emulate the PBX-compatible telephone going off-hook. This is also accomplished without having to manually take the PBX-compatible telephone off-hook.

Once a telephone call is connected to the analog telephone instrument via the interface device, the interface device provides a two-way communication path between the analog telephone instrument and the PBX for voice or modem signals. Thus, the interface device receives voice or modem signals from the analog telephone instrument and converts them into a form suitable for reception by the PBX and receives voice or modem signals from the PBX and converts them into a form suitable for reception by the analog telephone instrument. For

example, if the PBX is an all-digital PBX, the interface device performs appropriate analog-to-digital and digital-to-analog conversions.

When an incoming or outgoing telephone call is complete, the interface device detects that current is no longer drawn by the analog telephone instrument, as occurs when the analog telephone instrument is returned to its on-hook condition. In response, the interface device communicates an appropriate instruction to the PBX so as to emulate the PBX-compatible telephone returning to an on-hook condition.

A second embodiment differs from the first embodiment in that the keypad located on the PBX-compatible telephone is utilized to dial a telephone number to be called. According to the second embodiment, a keypad need not be provided on the interface device.

A third embodiment differs from the first and second embodiments in that a keypad located on the analog telephone instrument can be utilized to dial a telephone number to be called. The interface device receives dual-tone, multi-frequency (DTMF) signals which are generated by the analog telephone device as the telephone number is dialed. The interface device then converts these signals into a format appropriate for the PBX.

A fourth embodiment differs from the other embodiments in that the interface device communicates with the PBX so as to notify the PBX that the telephone connected to the extension line is capable of receiving incoming calls. Similar to the third embodiment, the keypad located on the analog telephone instrument can be utilized to dial a telephone number to be called. Thus, in the third embodiment, a PBX-compatible telephone is not required to be connected to the extension line along with the interface device.

In order to communicate voice and overhead signals with the PBX using a communication protocol appropriate to the PBX, the interface device must "learn" the characteristics of the PBX. Therefore, when the interface device is coupled to the PBX, a learning technique is performed.

A first step of the learning technique requires that the interface device determine whether or not the telephone system to which it is connected communicates voice signals as digital samples, such as an all-digital PBX or digital KTS, or whether the telephone system

communicates voice signals in analog form, such as a hybrid PBX, a hybrid KTS, or a central office of a telephone service provider. The primary functions of the telephone sets compatible with each of these types of telephone switching systems are powered directly by the associated telephone switching system. The inventor has observed that the power supply characteristics differ for each type of telephone switching system relative to the jack pinout (modular interface terminal locations) and the effective DC source resistances. Accordingly, a determination is made by the interface device polling the two to eight wires which couple to the extension line. By discovering which of the polled terminals are active, the interface device distinguishes between hybrid telephone switching systems and other types of telephone switching systems. Assuming the telephone switching system is a hybrid system, the particular model or manufacturer can generally be identified by discovering which polled terminals are active.

Assuming the telephone switching system is not a hybrid system, up to three DC source resistance measurements are taken for the extension line via the active terminals. A first measurement is an unloaded DC measurement. Thereafter, the system performs an unloaded AC measurement and analyzes the DC and AC results it to determine the signature of the system. For the next two measurements, the extension line is loaded by alternate fixed resistive loads. The interface compares the results of these measurements to pre-stored values to determine whether the telephone switching system is an all-digital system or an analog system.

If the system communicates voice signals in a multi-wire hybrid-type format, the interface device configures itself accordingly. Thus, a next step in the learning technique is to emulate an off-hook condition. In response to the emulated off-hook condition, the hybrid PBX provides a dial tone signal to the receive lines of the extension. The interface device detects the dial tone signal and performs level adjustments for both the receive and transmit signal paths. The receive signal path is configured using the dial tone signal and the transmit path is configured using a set of prestored parameters appropriate to the hybrid PBX. This is accomplished by the interface device selecting a stored set of operational parameters from a plurality of such sets.

If the system communicates voice signals in an analog format, the interface device also configures itself accordingly. Thus, a next step in the learning technique is to emulate an off-hook condition. In response to the emulated off-hook condition, the PBX analog line card or central office provides a dial tone signal to the interface device. The interface device detects the dial tone signal and performs level adjustments for both the receive and transmit signal paths. The receive path is configured using the dial tone signal and transmit path is configured using programmable sensitivity adjustments.

The AC analysis is performed prior to DC loading. If the system communicates voice signals as digital samples, the learning technique determines the signaling protocol which is utilized for communicating between the PBX and the associated PBX-compatible telephones. This is accomplished by the interface device momentarily open-circuiting the extension line. Then, the interface device monitors signals communicated between the PBX and the PBX-compatible telephone which initialize the PBX-compatible telephone and which notify the PBX that the PBX-compatible telephone connected to the extension line is capable of receiving incoming calls.

Then, based upon this determination, the interface device configures itself according to the appropriate signalling protocol. This is accomplished by the interface device selecting a stored set of operational parameters from a plurality of such sets. The sets of operational parameters are pre-stored in a memory device within the interface device. A selected set of operational parameters configures the interface device to communicate with the PBX using a protocol appropriate to the particular PBX being utilized.

Thus, the learning technique allows the interface device to automatically adapt itself to variations in signaling characteristics between the PBX and PBX-compatible telephone sets among the different PBX manufacturers.

Similarly, the interface device according to the present invention determines the communication protocol of any telephony appliance coupled to one of its ports. A telephony appliance can include an analog telephone, an analog conference call device, a fax machine, an analog headset, a modem of a computer, a PBX telephone configured for a different PBX, or

voice over IP (VoIP) calls received or sent via the internet 516 through the PBX. For an analog device, the protocol is merely the conventional two-wire or four-wire interconnection.

Brief Description of the Drawings:

Figure 1 shows a schematic block diagram of conventional telephony interfaces.

Figure 2 shows a schematic block diagram of a conventional PBX telephony interface.

Figure 3 shows a schematic block diagram of a telephony system.

Figure 4 shows a schematic block diagram of a telephony system providing a method of and apparatus for interfacing analog telephone apparatus to a digital, analog or hybrid telephone switching system.

Figure 5 illustrates a block schematic diagram of an interface device coupled to a PBX, to a PBX-compatible telephone set and to one or more analog telephone instruments.

Figure 6 illustrates a block schematic diagram of the interface control portion of the interface device.

Figure 7 illustrates a flow diagram of a learning algorithm.

Figure 8 illustrates a schematic diagram of a circuit for measuring a source resistance of the extension lines.

Figure 9 shows a schematic block diagram of telephony system according to the preferred embodiment of the present invention.

Detailed Description of a Preferred Embodiment:

This inventor invented and filed U.S. patent application no. 08/994,211 on December 19, 1997, and entitled Method and Apparatus for Interfacing Analog Telephone Apparatus to a Digital, Analog or Hybrid Telephone Switching System. That co-pending application is incorporated herein by reference. Among other things, that application describes a method and apparatus that allows interfacing conventional analog telephony equipment to a PBX. A simplified block diagram of that invention is shown in Figure 4. According to those teachings, an interface apparatus is coupled between a conventional analog telephony device and a digital,

analog or hybrid PBX 510. The conventional analog device can be an analog telephone 502, an analog conference call device 503, a fax machine 504, an analog headset 505 or a modem of a computer 506. That invention does not allow a user to couple a different PBX telephone 514 for use with the PBX 510. Nor does that invention allow a user to place or receive voice over IP (VoIP) calls through the internet 516 through the PBX 510.

Figure 5 illustrates a block schematic diagram of an interface device 100 coupled to a telephone switching system (PBX) 102, to a PBX-compatible telephone set 104, to a two-wire analog telephone instrument 106 and to a four-wire analog telephone instrument 108. The telephone switching system 102 can be an all-digital private branch exchange (PBX), a hybrid PBX, a key telephone system (KTS) or a direct line from a central office 110. For the purposes of this document, the term "PBX" encompasses all of the above-listed types of telephone switching equipment. And, for the purposes of this document, the term "PBX-compatible telephone set" refers to a telephone set 104 specifically designed to interface directly with a particular PBX 102. Typically, the PBX 102 and PBX-compatible telephone set 104 are provided by the same manufacturer. Though several manufacturers produce PBX's and corresponding PBX-compatible telephone sets, a PBX-compatible telephone set provided by a manufacturer is generally not capable of interfacing with a PBX provided by a different manufacturer.

The PBX 102 is coupled to a central office 110 of a telephone service provider via one or more outside lines 112 and is also coupled to a PBX port 114 of the interface device 100 via a extension line 116 and a wall jack 118. The extension line 116 is a two-wire or four-wire line for most types of telephone switching systems, however, the extension line 116 for a hybrid switching system can include up to eight wires.

As an example, the PBX 102 can be centrally located at a business site, such as in a service room or basement. Several extension lines (only one is shown - extension line 116) extend to corresponding wall jacks (only one is shown - wall jack 118). The wall jacks are typically distributed throughout the business site. The wall jacks can be located in users' offices, conference rooms and reception areas. Conventionally, the PBX-compatible telephone set 104

would be plugged into the wall jack 118. However, the interface device 100 is plugged into the wall jack 118, while the PBX compatible telephone set 104 is plugged into the interface device 100.

The interface device 100 includes an interface control portion 120 which is coupled to the PBX 102 via the PBX port 114. Internal to the interface device 100, the PBX port 114 is coupled to the interface control portion 120 and to a first terminal of a switch SW1. A second terminal of the switch SW1 is coupled to a PBX phone port 122. The switch SW1 is coupled to be controlled by the interface control portion 120. Also internally to the interface device 100, the interface control portion 120 is coupled to a two-wire analog phone port 124 and to a four-wire analog phone port 126.

Externally to the interface device 100, the PBX-compatible telephone set 104 is plugged into the PBX phone port 122, the two-wire analog telephone instrument 106 is plugged into the two-wire port 124 and the four-wire analog telephone instrument 108 is plugged into the four-wire port 126. In certain embodiments it is not necessary for the PBX-compatible telephone set 104 to always be present to obtain the advantages. In addition, it is not necessary that both telephone instruments 106, 108 be present to obtain the advantages.

The telephone instruments 106, 108 can each be a modem, fax modem, facsimile machine, teleconferencing device, headset, handset or other type of conventional analog telephone instrument. The four-wire telephone instrument 108 differs from the two-wire telephone instrument 106 primarily in that the four-wire telephone instrument 108 transmits analog signals via a first pair of wires and receives analog signals via a second pair of wires (uni-directional signaling), whereas, the two-wire telephone instrument 106 communicates analog signals in both directions (transmit and receive) via a single pair of wires (bi-directional signaling).

Figure 6 illustrates a block schematic diagram of the interface control portion 120 of the interface device 100 illustrated in Figure 5. A central office emulator 200 is coupled to the two-wire port 124 (Figure 5). The central office emulator 200 provides DC power to the port 124 and detects the on-hook/off-hook condition of the two-wire analog telephone instrument 106 (Figure

5) depending upon whether it draws current from the central office emulator 200. The central office emulator 200 provides an indication of the on-hook/off-hook condition of the two-wire analog telephone instrument 106 to a hook switch block 202. The central office emulator 200 also provides "ring" signals to the two-wire adjunct port and to the four-wire analog adjunct port via the two-to-four wire converter 204.

The central office emulator 200 is also coupled to a two-to-four wire converter 204. Internally to the central office emulator 200, signals from the two-wire port 124 are routed to the two-to-four wire converter 204. The two-to-four wire converter 204 can be a conventional circuit, commonly known as a hybrid circuit, which converts the bi-directional signals from the two-wire port 124 into separate transmit and receive signals. These separate transmit and receive signals from the two-to-four wire converter 204 are coupled to a TX/RX audio block 206.

The signals from the four-wire port 126 (Figure 5) are also routed to the TX/RX audio block 206. Two-to-four wire conversion is not required for these signals because they are already separated into transmit and receive channels. An indication of the on-hook/off-hook status for the four-wire telephone instrument can be provided by a user interface (not shown), such as a on/off switch, coupled to the hook switch block 202.

The TX/RX audio block 206 performs appropriate level adjustments for both the receive and transmit signal paths. Thus, the TX/RX audio block 206 includes analog signal processing circuits, such as gain-controllable amplifiers. The TX/RX audio block 206 ensures that the levels of the voice or modem signals received from the PBX 102 (Figure 5) are adjusted for compatibility with the analog telephone instrument 106 or 108 (Figure 5) and ensures that the levels of the signals received from the analog telephone instrument 106 or 108 are adjusted for compatibility with the PBX 102.

Via the TX/RX audio block 206, the separate transmit and receive signals from the two-to-four wire converter 204 and from the four-wire port 126 are coupled to a pulse code modulation (PCM) encoder/decoder (CODEC) block 208 and to an analog line interface block 210. Preferably, the PCM CODEC block 208 is selectively active or inactive depending upon whether the PBX 102 (Figure 5) communicates voice or modem signals over the extension line

116 (Figure 5) as digital samples or whether the PBX 102 communicates these signals in analog format. If the PBX 102 communicates these signals as digital samples, then the PCM CODEC block 208 is active. Conversely, if the PBX 102 communicates these signals in analog format, then the CODEC block 208 is inactive.

Assuming the PCM CODEC block 208 is active, a digital line transceiver 212 and digital line interface 214 are also active. The PCM CODEC block 208 converts analog voice or modem signals received from the TX/RX audio block 206 into a serial digital data stream. Preferably, this conversion is preformed according to A-LAW or μ-LAW companding techniques. The serial data stream formed by the PCM CODEC block 208 is representative of the voice or modem signal received from the analog telephone instrument 106 or 108 and is provided to the digital line transceiver 212.

The digital line transceiver 212 then combines the digitally sampled voice or modem signals with any necessary overhead or command signals, thereby forming a combined serial data stream. For example, the hook switch block 202 notifies the digital line transceiver 212 of the on-hook/off-hook status of the telephone instrument 106 or 108 (Figure 5). The digital line transceiver 212 responds by including an appropriate command to the PBX 102 in the combined serial data stream.

The combined serial data stream formed by the digital line transceiver 212 is then provided to the digital line interface block 214. The digital line interface block 214 communicates the combined serial data stream to the PBX via a learning block 216. The digital line interface 214 is preferably controlled by the learning block 216.

Because the combined serial data stream is received by the PBX 102 (Figure 5), it must be in a format that is compatible with, and understandable by, the particular PBX 102 coupled to the interface device 100. For example, the data must be appropriately synchronized with the PBX 102 and must be appropriately compressed and encoded according to the requirements of the PBX 102. In addition, the command and overhead information included in the combined serial data stream must be recognizable to the PBX 102.

The specific parameters required for appropriately forming the combined serial data stream, however, generally vary among the various manufacturers of PBX's. Therefore, the PCM CODEC block 208 and digital line transceiver 212 are preferably pre-configured to perform analog-to-digital conversion appropriately for the particular PBX 102 coupled to the interface device 100. In addition, the digital line interface 214 is also pre-configured to form the combined serial data stream appropriately for the particular PBX 102 coupled to the interface device 100. This pre-configuration of the PCM CODEC 208, digital line transceiver 212 and digital line interface 214 is performed under control of the learning block 216 and according to data stored in manufacturer specific protocol sets 218.

The digital line interface 214 receives a serial stream of digital data generated by the PBX 102 and provides this serial data stream to the digital line transceiver 212. The digital line transceiver 212 then appropriately separates overhead and commands from voice or modem signals and passes the voice or modem signals to the PCM CODEC 208 for decoding. To perform this function appropriately, the digital line transceiver 212 is pre-configured, under control of the learning block 214 according to data stored in the manufacturer specific protocols block 216.

As an example of operation of the digital line transceiver 212, if the PBX 102 indicates that an incoming telephone call is to be connected to the extension line 116, the digital line transceiver 212 recognizes this condition and, in response, communicates this condition to an incoming call detect block 220. The incoming call detect block 220 then notifies the PCM CODEC block 208 to prepare to receive digital samples from the digital line transceiver 212. The incoming call detect block 220 can also notify the central office emulator 200 to send a ring signal to the two-wire and four-wire analog telephone instruments 106 and 108 (Figure 5).

Then, when the two-wire analog telephone instrument 106 goes off-hook, the central office emulator 200 (Figure 6) recognizes this condition and, in response, notifies the hook switch block 202. Alternately, a manual switch notifies the hook switch block when the four-wire analog telephone instrument 108 (Figure 5) goes off-hook. The hook switch block 202 then

appropriately notifies the digital line transceiver 212 which then communicates with the PBX 102 so as to emulate the PBX-compatible telephone set 104 going off-hook.

The PCM CODEC block 208 converts the digital samples received from the digital line transceiver 212 into an analog signal. The digital samples are received as a one-bit-wide stream of digital values. Accordingly, the conversion is performed by appropriately parsing the received stream of digital values into a series of digital values, each digital value having an appropriate width. Then, any compression and/or encoding performed by the PBX 102 (Figure 5) is reversed. Finally, the analog signal is reconstructed from the series of digital values. To perform this conversion appropriately, the PCM CODEC block 208 is pre-configured, under control of the learning block 216 according to a manufacturer specific format and synchronization of the digital samples stored in the manufacturer specific protocols block 218.

The manufacturer specific protocol sets 218 includes a plurality of sets of conversion parameters appropriate for PBX's produced by various different manufacturers. Each set of parameters includes information relating to an appropriate format and synchronization of the digital samples, decompression and decoding of the digital samples, appropriate compression and encoding of the analog signals into digital samples, generation of commands to the PBX 102 and recognition of commands from the PBX 102. In general, these parameters are specific to each PBX manufacturer.

The analog signal generated by the PCM CODEC block 208 is provided to the TX/RX audio block 206 for routing to the two-wire port 124 via the central office emulator 200 and to the four-wire port 126.

In one possibility, a line filter 222 is coupled to the digital line interface 214 and to the analog line interface 210 for obtaining supply power for the interface device 100 (Figure 5) from the PBX 102 (Figure 5) via the extension line 116 (Figure 5). Preferably, the interface device 100 will be externally powered. The external power source will generate a DC voltage which can power a proprietary station set or for the two-wire and four-wire analog adjunct ports. The line filter 222 filters frequency components above a predetermined threshold from the extension line 116 thereby forming an unregulated DC voltage. Alternately, an unregulated DC voltage

can be obtained from a battery supply, from from a rectified AC line voltage or from an additional line pair provided by the PBX for supplying power. The unregulated DC voltage is provided to an isolated switching power supply 224. The isolated switching power supply 224 provides power to the circuits of the interface device 100, but is electrically isolated from the source of power. When the digital line transceiver 212 is active, the digital line transceiver 212 preferably provides a synchronizing signal to the switching power supply 224. This synchronizing signal controls switching of the power supply 224 to occur out of phase with digital-to-analog sampling performed by the PCM CODEC block 208 for minimizing sampling errors caused by switching noise.

Assuming that the PBX 102 communicates voice or modem signals in analog format, such as when an analog line card is used in the PBX 102 or when the PBX 102 is a hybrid switching system, the PCM CODEC block 208 is preferably inactive. The analog line interface 210 receives analog signals from the PBX 102 via a bi-directional communication path through the learning block 216. The analog line interface block 210 converts the bi-directional signals into separate uni-directional transmit and receive signal paths. Accordingly, the analog signals are communicated between the analog line interface block 210 and the TX/RX block 206 via separate uni-directional signal paths.

Separate uni-directional transmit and receive signal paths connect the TX/RX audio block 206 to the four-wire telephone instrument 108 (Figure 5). For the two-wire telephone instrument 106 (Figure 5), the two-to-four wire converter 204 converts the separate uni-directional signal paths coupled to the TX/RX audio block 206 into a bi-directional signal path through the central office emulator 200 that is multiplexed onto the CO emulator DC power supply.

The analog line interface block 210 monitors the signals originated by the PBX (Figure 5) for detecting commands from the PBX. For example, the analog line interface block 210 detects whether an incoming call is to be connected to the extension line 116. Assuming that the analog line interface block 210 detects an incoming call, the analog line interface block 210 notifies the incoming call detect block 220 of this condition. The incoming call detect block 220 then notifies the TX/RX audio block 206 to prepare to receive incoming voice signals from the PBX

102 (Figure 5). In response, the incoming call detect block 220 can also notify the central office emulator 200 to send a ring signal to the two-wire analog telephone instrument 106.

The analog line interface block 210 also combines the analog voice or modem signals received from the TX/RX audio block 206 with any necessary overhead or command signals. For example, the hook switch block 202 notifies the analog line interface 210 of the on-hook/off-hook status of the telephone instrument 106 or 108 (Figure 5). The analog line interface 210 responds by sending an appropriate command to the PBX 102, for example, by drawing a DC loop current from the PBX 102.

Note that for a hybrid PBX, the overhead and command signals sent to the PBX 102 may be in the form of serialized digital data, though the voice or modem signals are communicated in analog format. Generally the overhead and command signals for a hybrid system are communicated via separate wires within the extension line 116 (Fig.1) from the lines utilized for communicating voice signals. As mentioned, when the PBX 102 is a hybrid switching system, the voice signals are communicated between the PBX 102 and the analog telephone instrument via the analog line interface 210 and TX/RX audio block 206. For a hybrid switching system, however, a hybrid interface block 226 is provided for communicating overhead and command signals with the PBX 102. The hybrid interface block 226 is preferably pre-configured under control of the learning block 216 and according to data stored in manufacturer specific protocol sets 218.

As an example of operation of the hybrid interface block 226, when the PBX 102 sends a command that an incoming call is to be directed to the extension line 116, the hybrid interface block 226 notifies the incoming call detect block 220. Also, when the hook switch block 202 indicates to the hybrid interface block 226 that the analog telephone instrument 106 or 108 (Figure 5) is off-hook, the hybrid interface block 226 requests a dial tone from the PBX 102.

An FSK modem 232 is also coupled to the manufacturer specific protocol sets 218. The FSK modem 232 allows updates, additions, or modifications to be made to the manufacturer specific protocol sets 218 from a remote location over a telephone line connection or digital serial port connection such as a USB port.

According to one embodiment, a keypad 228 and a dual-tone, multi-frequency (DTMF) generator 230 are provided for initiating telephone calls from the analog telephone instrument 106 or 108 (Figure 5). The keypad 228 is coupled to the DTMF generator 230. The DTMF generator 230 is coupled to the TX/RX audio block 206 and to the PCM CODEC block 208. For example, to initiate a telephone call, the two-wire analog telephone instrument 106 is placed off-hook. In response, the central office emulator 200 notifies the hook switch block 202 of this condition. The hook switch block 202 then notifies the analog line interface 210, the digital line transceiver 212 and the hybrid line interface 226. An active one of the analog line interface 210 or the digital line transceiver 212 then sends an appropriate command to the PBX 102 (Figure 5) so as to emulate the PBX-compatible telephone set 104 (Figure 5) going off-hook. Once the PBX recognizes that call is to be initiated, the keypad 228 is utilized to dial the telephone number to be called. The DTMF generator 230 then generates dual tones for each digit of a telephone number dialed via the keypad 228.

In an alternate embodiment, the keypad 228 is replaced with a voice recognition block which converts a user's voice commands into signals appropriate for controlling the DTMF generator block 230. Such an embodiment could be utilized, for example, so that the user's hands remain free to perform other tasks, or could be utilized by persons having limited use of their hands.

The dual tones are then provided by the DTMF generator 230 to the TX/RX audio block 206 and to the PCM CODEC block 208. Assuming that the PBX 102 is an analog interface, the dual tones are passed to the PBX 102 through the analog line interface 210 and learning block 216. Otherwise, assuming the PCM CODEC block 208 is active, the dual tones are converted according to the protocol required for the particular PBX 102 (Figure 5) being utilized. Accordingly, the PCM CODEC block 208 is pre-configured for this conversion under control of the learning block 216 and according to data stored in manufacturer specific protocol sets 218. The appropriately converted dual tones are then passed to the PBX 102 via the digital line transceiver 212, the digital line interface 214 and the learning block 216.

A second embodiment differs from the first embodiment in that the keypad located on the PBX-compatible telephone set 104 (Figure 5) is utilized to dial a telephone number to be called. According to the second embodiment, therefore, the keypad 228 (Figure 6) and DTMF generator (Figure 6) 230 need not be provided.

A third embodiment differs from the first and second embodiments in that a keypad located on the analog telephone instrument 106 or 108 (Figure 6) can be utilized to dial a telephone number to be called. The interface device 100 (Figure 5) receives dual-tone, multi-frequency (DTMF) signals which are generated by the analog telephone device 106 or 108 (Figure 5) as the telephone number is dialed. An active one of the TX/RX audio block 206 (Figure 6) or PCM CODEC 208 (Figure 6) then converts these signals into a format appropriate for the PBX 102 (Figure 5).

A fourth embodiment differs from the other embodiments in that the interface device 100 (Figure 5) communicates with the PBX 102 (Figure 5) so as to notify the PBX 102 that the extension line 116 (Figure 5) is capable of receiving incoming calls. A keypad located on the analog telephone instrument 106 or 108 (Figure 5) or the keypad 226 (Figure 6) can be utilized to dial a telephone number to be called. Thus, in the third embodiment, a PBX-compatible telephone set 104 (Figure 5) is not required to be connected to the extension line 116 along with the interface device 100 (Figure 5).

When an incoming or outgoing telephone call is complete, the central office emulator 200 (Figure 6) of the interface device 100 (Figure 5) detects that current is no longer drawn by the analog telephone instrument 106 or 108, as occurs when the analog telephone instrument 106 or 108 is returned to its on-hook condition. In response, the central office emulator 200 (Figure 6) recognizes this condition and notifies the hook switch block 202 (Figure 6). The hook switch block 202 then notifies an active one of the digital line transceiver 212 or analog line interface 210, which then communicates with the PBX 102 so as to emulate the PBX-compatible telephone set 104 returning to its on-hook condition.

In order to appropriately configure the interface device 100 (Figure 5), particularly the PCM CODEC block 208, the digital line transceiver 212, the TX/RX audio block 206, the hybrid

line interface 226 and the analog line interface block 210 to communicate with the PBX 102 (Figure 5) according to a communication protocol appropriate to the particular PBX 102 being utilized, the interface device 100 must "learn" the characteristics of the PBX 102. To accomplish this, the interface device 100 performs a learning algorithm.

Figure 7 illustrates a flow diagram of a learning algorithm which controls operation of the learning block 216 (Figure 6) according to the present invention. The learning algorithm is initiated for appropriately configuring the interface device 100 (Figure 5). Thus, logic circuitry included in the learning block 216 perform the function of determining whether the telephone switching system 102 communicates voice signals as digital samples or in analog format. In addition, logic circuitry included in the learning block 216, in conjunction with data stored in the manufacturer specific protocol sets 218 (Figure 6), perform the functions of identifying a communication protocol utilized by the telephone switching system 102 and configuring the interface device 100 according to the protocol. It will be apparent, however, that a microprocessor or controller circuit operating according to a stored software program could also perform these same functions.

It will be appreciated that the interface device analyzes both the type of the line card of the PBX and also the type of telephone and telephony appliance being used. A flow chart depicting the steps for the operation of adaptive learning of the line card is shown in Figure 7. The communications to each of the station ports is open circuited in the step 320. The DC characteristics are learned from the line interface in the step 322. This DC characteristics learning step is performed by evaluating each pair of terminals in both polarities. Next, in the step 324 the AC characteristics (signaling characteristics) are learned from the line card. This AC characteristics learning step is also performed by evaluating each pair of terminals in both polarities. Waveforms and digital content are sampled and saved for use in determining the interface protocol.

Next, in the step 326, the sensed measurements are analyzed and compared to determine whether it matches a signature for a known protocol. If the measurements match a signature for a known protocol in the step 328, the appropriate protocol stack is loaded for use. Preferably, the

protocol stack is loaded into a non volatile memory such as a ROM, PROM, EPROM, EEPROM or Flash memory. On the other hand, if the measurements do not match a signature for a known protocol in the step 328, a DC load test is applied to the line card of the PBX to determine whether it is an analog or hybrid system in the step 332. Upon determination of the appropriate analog or hybrid system type, the interface device 100 is appropriately configured in the step 334.

Figure 8 illustrates a schematic diagram of a circuit for measuring a source resistance of the extension lines 116 (Figure 5). A DC voltage, Vsource, is provided by the PBX 102 (Figure 5) via a series resistance Rsource. A DC voltage, Vline, is received by the learning block 216 of the interface device 100 (Figure 5). A switch SW2 selectively coupled one of three resistive loads across the extension lines 116. A first load LOAD1 has a large resistance value (e.g. greater than 20 M ohms or open circuit) so as to leave the extension line essentially unloaded. Second and third loads LOAD2 and LOAD3 have alternate values which are lower than the value of LOAD1 so as to the load the extension lines to varying degrees. For example, the value of LOAD2 can be comparable to an expected value of the source resistance Rsource for an analog interface (e.g. approximately 1 K ohms), while the value of LOAD3 can be comparable to an expected value of the source resistance Rsource for an all-digital interface (e.g. approximately 50 ohms), but is preferably a higher resistance to avoid any potentially excessive flow of current.

In the state 332, three DC source resistance measurements are taken for the extension line 116 (Figure 5) via the active two terminals of the PBX port 114 (Figure 5). A first measurement is an unloaded DC measurement. For this measurement, the switch SW2 is coupled to the first resistance LOAD1 and the resultant level of the voltage Vline is detected. Similarly, for the second measurement, the switch SW2 is coupled to the second resistance LOAD2 and the resultant level of the voltage Vline is detected. For the third measurement, the switch SW2 is coupled to the third resistance LOAD3 and the resultant level of the voltage Vline is detected. For each measurement the value of Vline is influenced by the relative values of Rsource and the resistance value coupled to the switch SW2 by voltage division.

Because the results of the measurements taken in the state 332 are indicative of the values of Rsource and Vsource, the interface device 100 compares the results of these measurements, or ratios thereof, to pre-stored values to determine whether the telephone switching system is an all-digital system or an analog system. If the comparison made in the state 332 indicates that the PBX 102 (Figure 5) communicates voice and control signals in the analog domain, the learning algorithm moves from the state 332 to a state 334.

By way of performing an AC analysis, the PBX 102 (Figure 5) detects that the PBX-compatible telephone set 104 has been disconnected. In response, the PBX 102 attempts to communicate with the PBX-compatible telephone set 104 to initialize the PBX-compatible telephone set 104. These initialization signals differ among the various manufacturers and models of PBX's. Therefore, they provide indicia (a "signature") by which the particular PBX manufacturer and model can be recognized.

In the state 326, the interface device 100 (Figure 5) monitors the indicia provided by these initialization signals communicated from the PBX 102 (Figure 5) to a PBX-compatible telephone set 104 (Figure 5) and compares them to pre-stored indicia. Each pre-stored indicia is stored in the manufacturer specific protocol sets 218 in association with a corresponding one of the sets of parameters utilized for appropriately configuring the interface device 100 (Figure 5). Then, the learning algorithm moves to a state 328. Assuming that the interface device 100 recognizes the indicia (the "signature") provided by the initialization signals, the interface device 100 configures itself according to the appropriate signaling protocol.

In the state 330, the learning block 216 selects an appropriate stored set of operational parameters from a plurality of such sets pre-stored in the manufacturer specific protocol sets 218 and appropriately configures the PCM CODEC 208 and digital line transceiver 212 according to the selected set. Then, the learning algorithm moves from the state 330 to a state 342.

In the preferred embodiment, once the interface device 100 (Figure 5) is appropriately configured for the particular PBX 102 (Figure 5) being utilized, a verification is performed. Therefore, in the state 342, the interface device 100 sends a command to the PBX 102 (Figure 5) which simulates the PBX-compatible telephone set 104 (Figure 5) going off-hook. Then, the

learning algorithm moves from the state 342 to a state 344. In the state 344, the interface device 100 determines whether the PBX 102 is providing a dial tone in response to the command sent in the state 330. Assuming a dial tone is detected, the learning algorithm moves to state 346 which signifies that the learning algorithm is complete. Also in the state 346, the protocol and system configuration parameters are preferably stored in non-volatile memory, such as a serial EEPROM or Flash memory, so that they will not be lost in the event of a power failure.

Alternately, if in the state 344, a dial tone is not detected, or, if in the state 330, the interface device 100 does not recognize the indicia (the "signature") the learning algorithm returns to the state 320, and learning algorithm begins again. If the interface device 100 is not appropriately configured after a predetermined number of attempts, then the interface device 100 preferably indicates an error condition.

Assuming the PBX 102 (Figure 5) communicates voice signals in an analog format, the interface device 100 (Figure 5) configures itself accordingly. Thus, if it is determined in the state 332 that the PBX 102 communicates voice signals in an analog format, the learning algorithm moves from the state 332 to a state 334. In the state 336, the interface device 100 emulates an off-hook condition. In the preferred embodiment, this is accomplished by placing an appropriate resistance across the extension lines 116 so that the PBX 102 senses a current draw via the extension lines 116. Then, the learning algorithm moves from the state 336 to a state 338.

In response to the emulated off-hook condition, the PBX 102 (Figure 5) is expected to provide a dial tone signal to the extension lines 116 (Figure 5). Accordingly, in the state 338, the interface device 100 determines whether the dial tone is detected. Assuming that the dial tone is detected, the learning algorithm moves from the state 338 to a state 340.

In the state 334 and based upon the level of the dial tone signal, the interface device 100 performs level adjustments for both the receive and transmit signal paths through TX/RX audio block 206 of the interface device 100. The receive path is appropriately configured first utilizing the dial tone. Then, using side tone characteristics linking the receive and transmit paths, the transmit path is appropriately configured. The transmit path is preferably configured by implementing Transmit Objective Loudness Rating (TOLR) sensitivity levels. Once the

transmit and receive paths have been appropriately configured, the learning algorithm moves to state 340 which signifies that the learning algorithm is complete. Also in the state 340, the protocol and system configuration parameters are preferably stored in non-volatile memory, such as a serial EEPROM or Flash memory, so that they will not be lost in the event of a power failure.

In addition to examining the nature of the PBX to which it is attached, the present invention also capable of examining the equipment attached to it. Figure 9 shows a schematic block diagram of an exemplary system incorporating the present invention. A central office 500 is coupled to provide telephone service to a user's facility via the public switched telephone network (PSTN). A conventional PBX 510 is coupled to the CO 500. The PBX is coupled to an interface device 806 of the present invention. The interface device 806 is configured to communicate with each of an analog telephone 502, an analog conference call device 503, a fax machine 504, an analog headset 505, a modem of a computer 506, a different PBX telephone 514, and a VoIP telephone through the internet 516 or an IP telephony gateway. For purposes of the discussion to follow, these devices are collectively referred to herein as telephony appliances.

In addition, a telephony gateway 804 is coupled to the PBX 510 and also to the interface device 806. A router (or bridge) 800 is also coupled to the CO 500. The router (or bridge) 800 is coupled to the gateway 804 via a local area network 802 of any type such as Ethernet, Token Ring, ATM, etc. One or more computers 506 can be coupled to the LAN 802 as is well known. The gateway 802 is coupled to one or more analog telephones 502. Likewise, one or more of the computers 506 can include a voice processing circuit to provide VoIP features. A proprietary telephone station set can be configured to communicate directly with the IP telephony gateway. When this occurs, the proprietary telephone station set becomes a VoIP terminal.

The techniques for analysis to determine the type of telephony appliance, though similar, are not identical to those described above. Unlike a PBX 510, many telephony appliances do not provide signals that can be analyzed. This is especially true of telephone sets 502, 508 and 514 which, for the most part receive power from the PBX 510 or CO 500 depending upon phone type. Initially, power is applied from the interface device 510 to a telephony appliance. The port

from the interface device 510 to a telephony appliance will have a predetermined number of connectors, from two to eight. For some telephony appliances, only two of these connectors will be in use. For other telephony appliances all eight connectors will be used. The interface device 806 begins applying a relatively limited amount of voltage and current to pairs of connectors on the port. Each set of connector pairs will be measured. If no meaningful measurement is taken, the test voltage will be incremented and the test repeated until the nature of the telephony appliance is determined.

Once the telephony appliance is identified, the appropriate communication protocol can be loaded for that port. This allows the interface device 806 to translate between the communications protocol for the PBX 510 and for each telephony appliance connected thereto. For many applications an interface device will be utilized at a user's desk top such that a single telephone and single analog device will be coupled to the interface device 806. Then two communication protocols need be loaded, one for the communication protocol for the PBX 510 and a second communication protocol for the telephony appliance. The conventional analog communication protocol is typically always present and available for a conventional analog device.

However, it should be recognized that other applications exist for the interface device 806 of the present invention. For example, it is well known that PBX telephone station sets are quite expensive. Where a company decides to replace its PBX for another, the considerable investment in station sets would heretofore be wasted. For such an application, it may be desirable to provide an interface device for each telephone in a facility. When this occurs, it may be desirable to provide a multi-user interface device 806 having many ports in the 'back room', likely adjacent or integral to the PBX.

It is possible for each port coupled to the interface device 806 to communicate according to a different communication protocol. In such a case, it is possible to utilize a separate non volatile memory device such as ROM, PROM, EPROM, EEPROM or Flash memory for each such port to store the appropriate communication protocol. Such an occurrence is unlikely; generally PBX 510 systems will utilize telephony appliances having only one or two

communication protocols. Presuming this is true, the interface device 806 can be configured to share flash memory devices among its various ports.

As described above, the interface device 806 automatically determines the communication protocol of the PBX 510. The interface device 806 similarly, automatically determines the communication protocol of each telephony appliance attached thereto, including whether that telephony appliance communicates via conventional analog telephony protocols. The interface device 806 then automatically translates between those identified communication protocols.

The present invention has been described in terms of specific embodiments incorporating details to facilitate the understanding of the principles of construction and operation of the invention. Such reference herein to specific embodiments and details thereof is not intended to limit the scope of the claims appended hereto. It will be apparent to those skilled in the art that modifications may be made in the embodiment chosen for illustration without departing from the spirit and scope of the invention. Specifically, it will be apparent to one of ordinary skill in the art that the method of the present invention could be implemented in several different ways and the apparatus disclosed above is only illustrative of the preferred embodiment of the present invention and is in no way a limitation.